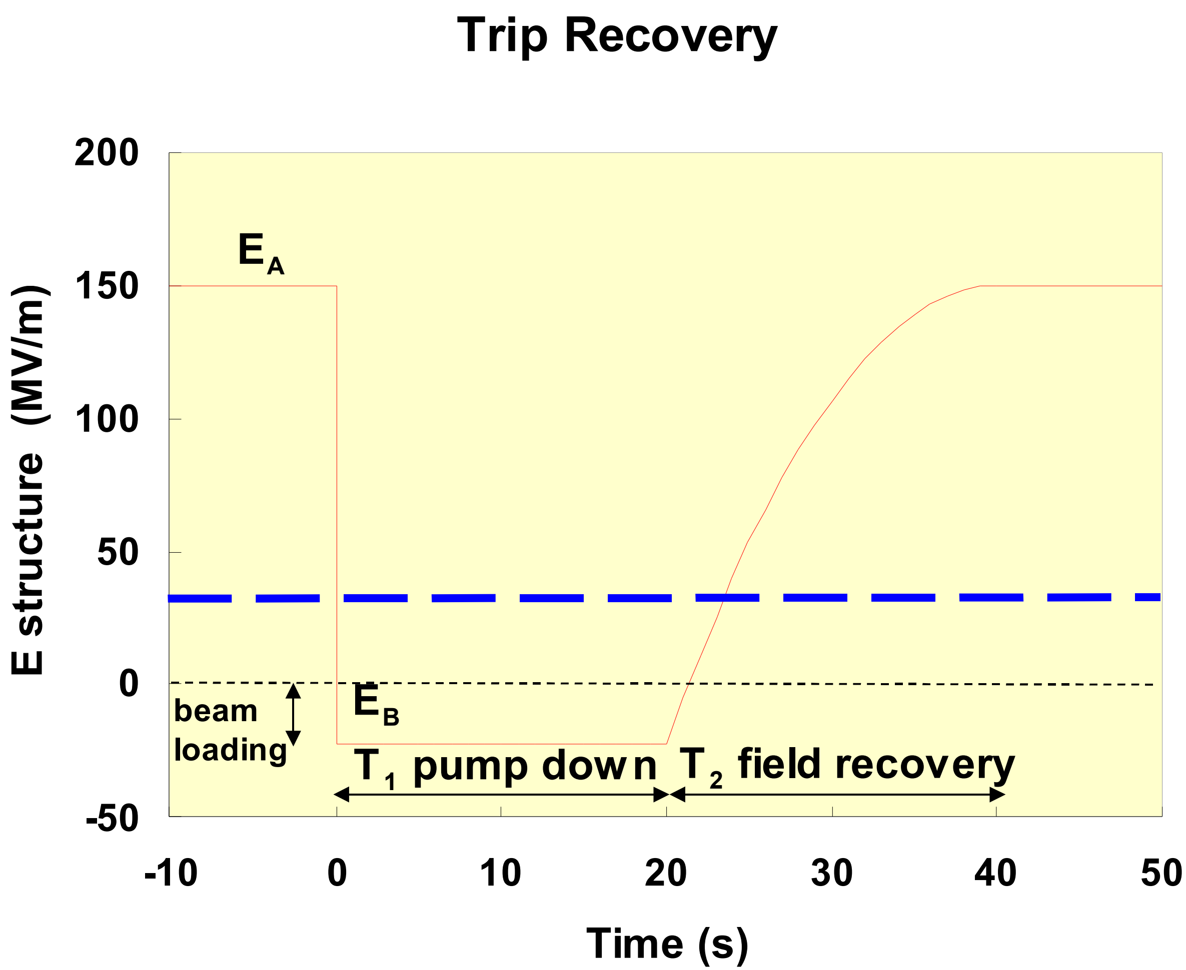
H.H. Braun, CLIC meeting, 20.2.2004

Permissible Trip Rates for 30 GHz structures in CLIC

- What is the permissible trip rate as a function of linac energy overhead ?
- What is the permissible trip rate if break-down affects beam quality ?

Permissible Trip Rate as a Function of Linac Energy Overhead



$$\bar{E} = \frac{T_1 E_B + \frac{1}{3} T_2 (E_B + 2 E_A)}{T_1 + T_2}$$

This requires that PETS can be switched off from one pulse to next and that field can be ramped with constant phase !

A small fraction $\boldsymbol{R}$ of the total number of installed structures $\boldsymbol{N}$ is reserve.
If no structure has tripped they are not fed with power, but decelerate with the beam loaded Voltage $\boldsymbol{V_{B}}$. They are switched on to compensate the energy loss due to tripped structures.
During the recovery cycle the tripped structures accelerate in average with $\bar{\boldsymbol{V}}$

This implies
$$N_{Trip} < R\,N\,\frac{V_A - V_B}{V_A - \bar{V}}$$

If $\boldsymbol{X}$ is the probability that a structure break down in a pulse, we will have in average

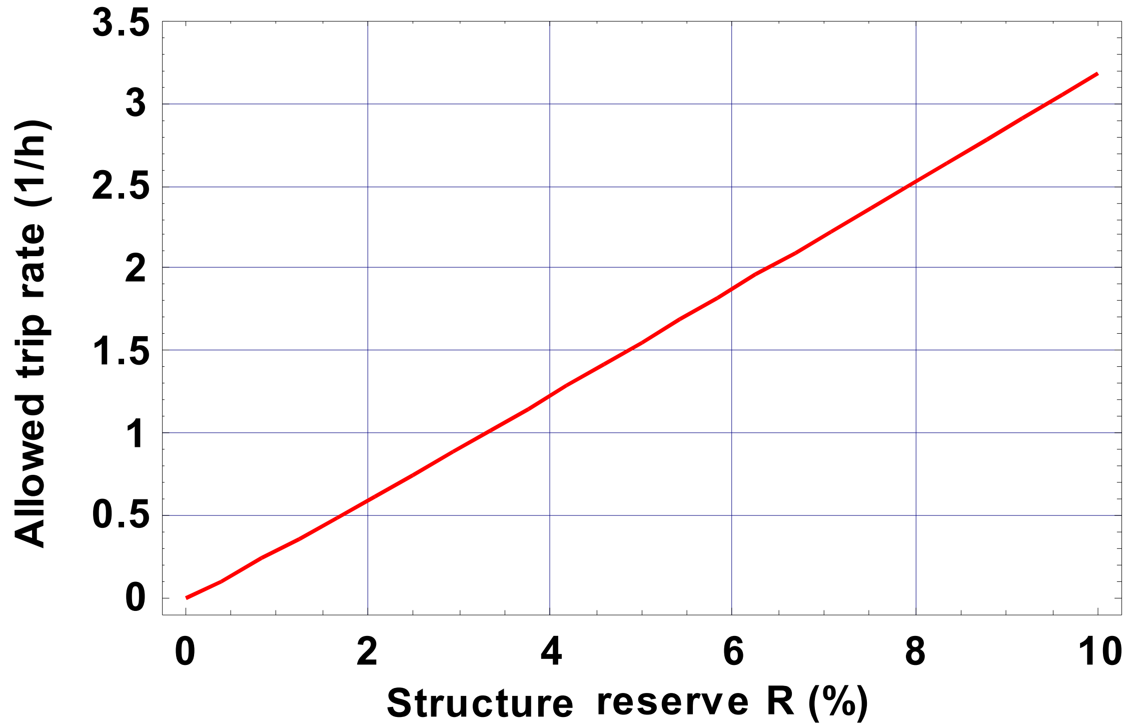
$$\langle N_{Trip} \rangle = N\,M\,X\,(T_1 + T_2)\,\nu_{REP}$$

with $\boldsymbol{M}$ the number of structures connected to a PETS. Since N_{Trip} is a random number it will scatter around this value with a standard deviation $N_{Trip}^{1/2}$.
Assuming that we want to cope with 6 standard deviations from $\langle N_{Trip} \rangle$ we get the condition

$$X \le \frac{18 + N\,R\,H - 6\sqrt{9 + N\,R\,H}}{N\,M\,\nu_{REP}\,(T_1 + T_2)} \quad \text{with} \quad H = \frac{V_A - V_B}{V_A - \bar{V}}$$

With

$\boldsymbol{L}$=0.3 m
$\boldsymbol{E_A}$=150 MV/m
$\boldsymbol{E_B}$=-22 MV/m
$\boldsymbol{N}$=3 TeV/(L E_A)=66666
$\boldsymbol{M}$=4
$\boldsymbol{T_1}$=20 s
$\boldsymbol{T_2}$=20 s



What is the permissible trip rate if break-down affects beam quality ?

The vertical momentum of the beam electrons have a gaussian distribution with

$$\sqrt{\left\langle \boldsymbol{P_Y}^2 \right\rangle} = \boldsymbol{P_Z} \sqrt{\frac{\varepsilon_Y}{\gamma \ \beta_Y}}$$

this r.m.s. value varies along the linac in the range 5-35 keV/c

Each single cell of an accelerating structure increases P_Z by 500 keV/c.
A change of field direction in a single cell by 2^0 during a breakdown event is therefore sufficient to bring the beams out of collisions during this pulse.

If a field distortion of this magnitude occurs, the implication is that all machine pulses with a break-down in a single structure are lost for luminosity.

If this is true the permissible breakdown rate for a 1% luminosity loss is

$$\boldsymbol{X} < \frac{1}{100\,\boldsymbol{N}}$$ corresponding to a trip rate of **< 0.05/h**